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(54) **Improved intra-cell call hand-over in radio communication systems with dynamic channel allocation**

Verbessertes Weiterreichen von Gesprächen zwischen Zellen in Funkkommunkationssystemen mit dynamischer Kanalzuteilung

Transfert d'appel amélioré entre cellules dans des systèmes de radio-communications avec allocation dynamique de canal

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(73) Proprietor: **NORTHERN TELECOM LIMITED**
Montreal, Quebec H2Y 3Y4 (CA)

(72) Inventors:
- **Strawczynski, Leo**
  Ottawa, Ontario K2A 2J5 (CA)
- **Plett, Gregory Loren**
  North Gower, Ontario K0A 2T0 (CA)
- **Sandler, Howard Martin**
  Ottawa, Ontario K2P 2G2 (CA)
- **Steer, David Gwyn**
  Nepean, Ontario (CA)

(74) Representative: **Dennis, Mark Charles et al**
Nortel Patents,
London Road
Harlow, Essex CM17 9NA (GB)

(56) References cited:
EP-A- 0 209 185
EP-A- 0 244 872
GB-A- 2 250 665
US-A- 4 672 657

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Description

Field of the Invention

This invention relates to radio communication systems which use dynamic channel allocation, especially, but not restricted to, cellular radio systems.

Description of the Prior Art

A duplex radio link conveying user analogue and/or digital information shall henceforth be referred to as a "call". An example is a telephone call over a wireless channel.

Cellular radio communication systems are able to service a high volume of traffic with a limited amount of radio spectrum by re-using the same radio channels in sufficiently separated cells. In conventional city-wide mobile cellular systems, such as the North American Advanced Mobile Phone System, the frequency allocations for a specific cell are fixed; i.e., each cell can make use of only a specified subset of channels of those allocated to the entire service. The allocations of channels require careful engineering analyses of radio propagation conditions and traffic patterns within and between the cells. Fixed allocation cellular radio systems are engineered so that harmful levels of interference from signals used in neighbouring cells are unlikely to be encountered.

When a subscriber terminal moves out of the coverage area of one base station and into that of another, the call may be maintained by switching the communication link to the closer base station. This is known as an "inter-cell" hand-over, i.e., between cells. A description of an inter-cell call handover is disclosed in a co-pending application entitled "Improved Inter-cell Call Handover in Radio Communication Systems With Dynamic Channel Allocation", filed on December 5, 1990, (European Patent Application No EP-A-0 492 800). On the other hand, when the communication link changes channels without changing the base station that communicates with the subscriber, it is known as an "intra-cell" hand-over, i.e. within a cell. Intra-cell call handovers are usually necessitated by the presence of interference on the channel.

Micro-cellular radio systems tend to use dynamic, rather than fixed, channel allocation. With dynamic channel allocation (DCA) each cell can potentially use any traffic channel for a given call of those allocated to the entire service. The decision as to which channel to use is made dynamically, i.e., based on channel usage conditions experienced at the time of call set-up. The decision is also made in a decentralized manner, i.e., by the base station or subscriber terminal in question, without any centralized coordination with other cells. This has the advantages that no detailed engineering analyses are required for each cell site, cell sites can be easily added or moved, and more traffic can be handled than with fixed allocation because channels unused in neighbouring cells can be "borrowed".

Examples of radio systems which use DCA are the digital U.K. CT2 system, and some models of analogue North American 46/49 MHz cordless telephones. In present systems incorporating DCA, the determination of which channel is used for a call set-up or hand-over is made according to channel information from either the base station or the subscriber terminal. The disadvantage with this approach is that appreciable interference may be present on that channel from the viewpoint of the other end of the link. For example, a traffic channel may have little appreciable interference, as monitored by the base station. However, the same traffic channel may have unacceptable interference at the subscriber terminal. Therefore, the presence of interference may reduce the quality of the link and also make it more susceptible to any further channel impairments which might arise.

There is accordingly a need for an intra-cell hand-over which allows for the selection of other traffic channels suitable for transmission at the both ends of the transmission link when the signal quality on the current traffic channel deteriorates beyond an acceptable level.

Summary of the Invention

According to the present invention there is provided method of completing an intra-cell call hand-over from a current traffic channel in use between a base station and a subscriber terminal to a standby traffic channel in a radio communication system, the method comprising:

selecting a first group of standby traffic channels determined to be useable at the base station;
monitoring tne signal quality on the current traffic channel;
sending a request for a new traffic channel if the signal quality on the current traffic channel deteriorates to an unacceptable level; and
switching the base station and the subscriber terminal to one of the standby traffic channels selected from said first group of traffic channels,

characterised by:

sending a message to the subscriber terminal along an inband signalling channel linking the base station and the subscriber terminal, the message being indicative of said first group
receiving the message at the subscriber terminal;
selecting from said first group a second group of standby traffic channels determined to be useable at the subscriber terminal;
forwarding to the base station along the inband signalling channel a response message being indicative of the standby traffic channels of said second group which were determined to be useable at the

subscriber terminal;
said one standby traffic channel being selected from said second group.

Brief Description of the Drawings

Figures 1 and 2 are illustrations of a radio systems embodying the invention;
Figure 3 is an illustration of the frame structure of a traffic channel; and
Figures 4a, 4b and 4c are flow diagrams illustrating the intra-cell call hand-over procedures of the present invention.

Description of the Preferred Embodiment

In the illustration of Figure 1, a low-power wireless communication system is shown. A typical network can consist of small base station 11a connected to the Public Switched Telephone Network (PSTN) 12 and base stations 11b and 11c connected to the PSTN 12 via an office PBX 13. The base stations are basically used as radio transceivers. These can be deployed in offices, residences, and public areas, such as airports, gas stations and shopping malls, etc. The base stations 11a, 11b and 11c, form the interface between a number of subscriber terminals such as portable handsets 14a, 14b and 14c and PSTN 12. Several base stations can also be linked to a host, such as a private branch exchange PBX 13 to provide coverage of larger areas in, say, a private business or office building. Such a wireless PBX system is disclosed in US patent 4,771,448.

It has been demonstrated that a radio link between a base station and a subscriber terminal may be established which, although it may be free of interference upon call set-up, may be affected by interference sometime thereafter, for example, another call is set-up in a neighbouring cell on the same channel, therefore reducing the overall quality of the link.

Referring now to Figure 2, we have shown a low power wireless communication system which be installed in a private business or office building. A PBX 20 is used by a wired telephone set 21 and a wireless subscriber terminal 22 to establish call connections to PSTN 23. Base stations 24a and 24b can be placed at various locations in the office building to allow the use of a wireless subscriber terminal 22 where required. In the illustration, subscriber terminal 22 is being served by base station 24a on a selected traffic channel 25. Each base station continuously scan or periodically scans a list of traffic channels for the selection of standby traffic channels which may be used when an intra-cell call hand-over becomes necessary. With the embodiment of the present invention, the base stations 24a and 24b would scan all available traffic channels, and select standby traffic channels that are useable or free of interference at the base station's end of the link. A list of standby traffic channels is made and forwarded to subscriber terminals via an inband or associated signalling channel linking the base station and the subscriber terminals. Once received, the list of standby traffic channels, is scanned by subscriber terminals. The subscriber terminals can then select standby traffic channels which are also free of interference at the subscriber end of the link. The preferred standby channel is selected and acknowledged to the base stations, again via the inband or associated signalling channel. This process of query by the base stations and response by the subscriber terminals may occur routinely throughout the time the call is in progress and more particularly, whenever the status of the preferred standby traffic channel changes.

In the event that interference arises on the communication channel linking the base station and the subscriber terminal, an intra-cell hand-over may be necessary. That is, another channel without interference would be selected. For example, in Figure 2, a new subscriber terminal 26 is requesting access to a traffic channel with base station 24b. If the selected traffic channel 27 between the base station 24b and the subscriber terminal 26 is on the same frequency as the traffic channel 25, interference can exist if subscriber terminal 26 is too close to base station 24a, or if subscriber terminal 22 is too close to base station 24b. Thus, an intra-cell hand-over would be necessary. In the event that the signal quality deteriorates on traffic channel 25, a request to switch to a new channel would be initiated by either the subscriber terminal 22 or its base station 24a. When an intra-cell call hand-over occurs, both the subscriber terminal 22 and base station 24a switch over to the standby traffic channel.

In the preferred embodiment, the base stations 24a and 24b would be designed to prescan all traffic channels and select 3 standby traffic channels which have the lowest level of interference. The list of 3 standby channels would be made available to the subscriber terminals and the preferred standby channel would be selected. Thus, if a request for a new channel is received, a hand-over can quickly be initiated to the selected standby channel without the delay needed to find another traffic channel.

The signalling and traffic channels of the wireless communication system may be used in time-division duplex mode. That is, base station and subscriber terminal share the same carrier frequency but alternately transmit so that their transmissions do not overlap. This technique is commonly referred to as "ping-pong". This is shown in Figure 3.

As shown in Figure 3, the frame structure comprises one time slot 42 for outbound communication from the base stations to the subscriber terminals and another time slot 43 of the frame is used for inbound communication from the subscriber terminals to the base stations. Each slot in a frame consist of a voice or data portion 44 and an inband or associated signalling D-channel comprised of two sets of bits 45a and 45b. In the preferred embodiment, the voice or data portion con-

tains 64 bits of information per frame and the inband or associated signalling channel contain 4 bits of information per frame. In Figure 3, the two sets of signalling bits 45a and 45b are separated by the voice or data portion 44, such that 2 bits of signalling information is first sent, followed by 64 bits of voice or data and then another 2 bits of signalling information. It will be known to those knowledgeable in this art, that the inband or associated signalling D-channel is a duplex channel, i.e. wherein one frame 42 is used for one-way communication from the base station to the subscriber terminal and one frame 43 used for one-way communication from the subscriber terminal to the base station.

Figures 4a, 4b and 4c illustrate the flow of information between the base station and a subscriber terminal prior to and during an intra-cell call hand-over. In Figure 4a, the process of standby traffic channel selection is illustrated. In Figure 4b, the subscriber terminal sends a request for an intra-cell call hand-over. In Figure 4c, the base station sends the request for an intra-cell call hand-over.

The measurement of the interference power present in each of standby traffic channels would be carried out by a receiver at the base station on a frequent basis. The receiver which carries out the scan could be, but need not be, the same receiver which communicates with the subscriber terminal.

Claims

1. A method of completing an intra-cell call hand-over from a current traffic channel in use between a base station and a subscriber terminal to a standby traffic channel in a radio communication system, the method comprising:

   selecting a first group of standby traffic channels determined to be useable at the base station;
   monitoring the signal quality on the current traffic channel;
   sending a request for a new traffic channel if the signal quality on the current traffic channel deteriorates to an unacceptable level; and
   switching the base station and the subscriber terminal to one of the standby traffic channels selected from said first group of traffic channels,

   characterised by:

   sending a message to the subscriber terminal along an inband signalling channel linking the base station and the subscriber terminal, the message being indicative of said first group
   receiving the message at the subscriber terminal;
   selecting from said first group a second group of standby traffic channels determined to be useable at the subscriber terminal;
   forwarding to the base station along the inband signalling channel a response message being indicative of the standby traffic channels of said second group which were determined to be useable at the subscriber terminal;
   said one standby traffic channel being selected from said second group.

2. A method as defined in claim 1, characterised in that said first group of standby traffic channels is selected by:

   scanning, at the base station, each of the traffic channels in said plurality of traffic channels;
   measuring the interference level of each traffic channel; and
   identifying the traffic channel as a useable standby traffic channel if the interference level is below a first predetermined threshold.

3. A method as defined in claim 2, characterised in that additional useable standby traffic channels are selected from the plurality of traffic channels available for service if an inadequate number of the standby traffic channels were found to have interference levels below the first predetermined threshold.

4. A method as defined in claim 3, characterised in that if the additional useable standby traffic channels are selected, the addititional useable standby traffic channels having the lowest interference level above the first predetermined threshold will be selected.

5. A method as defined in claim 4, characterised in that if any remaining standby traffic channels have an excessive level of interference considered to offer inadequate communication between the base station and the subscriber terminal, they will be excluded from the selection.

6. A method as defined in any preceding claim, characterised in that said message is sent to the subscriber terminal by:

   storing said first group of standby traffic channels; and
   forwarding to the subscriber terminal a list of said first group of standby traffic channels.

7. A method as defined in claim 6, characterised in that standby traffic channels on the list are determined to be useable at the subscriber terminal by:

   scanning each of the standby traffic channels of said first group identified on the list;

measuring the interference level of each of the standby traffic channels;
selecting the standby traffic channel with the lowest level of interference; and
storing the selected standby traffic channel.

8. A method as defined in claim 6 or claim 7, characterised in that the standby traffic channels on the list are determined to be useable at the subscriber terminal by:

scanning each of the standby traffic channels of said first group identified on the list;
measuring the interference level of the the standby traffic channels;
selecting, while the standby traffic channels are being scanned, a first standby traffic channel found to have an interference level below a second threshold; and
storing the selected standby traffic channel.

Patentansprüche

1. Verfahren zur Durchführung einer zellenintemen Gesprächsverbindungsübergabe von einem derzeitigen Verkehrskanal, der zwischen einer Basisstation und einem Teilnehmer-Endgerät in Gebrauch ist, auf einen Bereitschafts-Verkehrskanal in einem Funkkommunikationssystem, wobei das Verfahren die folgenden Schritte umfaßt:

Auswahl einer ersten Gruppe von Bereitschafts-Verkehrskanälen, die an der Basisstation als brauchbar bestimmt wurden,
Überwachung der Signalqualität auf dem derzeitigen Verkehrskanal,
Aussenden einer Anforderung für einen neuen Verkehrskanal, wenn die Signalqualität auf dem derzeitigen Verkehrskanal sich auf einen unannehmbaren Pegel verschlechtert, und
Umschalten der Basisstation und des Teilnehmer-Endgerätes auf einen der Bereitschafts-Verkehrskanäle, der aus der ersten Gruppe von Verkehrskanälen ausgewählt ist,

gekennzeichnet durch:

Aussenden einer Nachricht an das Teilnehmer-Endgerät entlang eines die Basisstation und das Teilnehmer-Endgerät verbindenden Inband-Signalisierungskanals, wobei die Nachricht die erste Gruppe anzeigt,
Empfangen der Nachricht an dem Teilnehmer-Endgerät,
Auswahl einer zweiten Gruppe von Bereitschafts-Verkehrskanälen, die an dem Teilnehmer-Endgerät als brauchbar bestimmt wurden, aus der ersten Gruppe,
Zuführen einer Antwortnachricht an die Basisstation entlang des Inband-Signalisierungskanals, wobei diese Antwortnachricht die Bereitschafts-Verkehrskanäle der zweiten Gruppe anzeigt, die an dem Teilnehmer-Endgerät als brauchbar bestimmt wurden,
wobei der eine Bereitschafts-Verkehrskanal aus der zweiten Gruppe ausgewählt wird.

2. Verfahren nach Anspruch 1,
dadurch gekennzeichnet, daß die erste Gruppe von Bereitschafts-Verkehrskanälen dadurch ausgewählt wird, daß

an der Basisstation jeder der Verkehrskanäle in der Vielzahl von Verkehrskanälen abgetastet wird,
der Störpegel auf jedem Verkehrskanal gemessen wird, und
der Verkehrskanal als brauchbarer Bereitschafts-Verkehrskanal identifiziert wird, wenn der Störpegel unterhalb eines ersten vorgegebenen Schwellenwertes liegt.

3. Verfahren nach Anspruch 2,
dadurch gekennzeichnet, daß zusätzliche brauchbare Bereitschafts-Verkehrskanäle aus der Vielzahl von für den Dienst verfügbaren Verkehrskanälen ausgewählt werden, wenn festgestellt wird, daß eine unzureichende Anzahl von Bereitschafts-Verkehrskanälen Störpegel unterhalb des ersten vorgegebenen Schwellenwertes aufweist.

4. Verfahren nach Anspruch 3,
dadurch gekennzeichnet, daß wenn die zusätzlichen brauchbaren Bereitschafts-Verkehrskanäle ausgewählt werden, die zusätzlichen brauchbaren Bereitschafts-Verkehrskanäle mit dem niedrigsten Störpegel oberhalb des ersten vorgegebenen Schwellenwertes ausgewählt werden.

5. Verfahren nach Anspruch 4,
dadurch gekennzeichnet, daß wenn irgendwelche verbleibenden Bereitschafts-Verkehrskanäle einen übermäßigen Störpegel aufweisen, von dem angenommen wird, daß er eine unzureichende Kommunikation zwischen der Basisstation und dem Teilnehmer-Endgerät ergibt, diese Bereitschafts-Verkehrskanäle aus der Auswahl ausgeschlossen werden.

6. Verfahren nach einem der vorhergehenden Ansprüche,
dadurch gekennzeichnet, daß die Nachricht an das Teilnehmer-Endgerät dadurch ausgesandt wird, daß:

die erste Gruppe von Bereitschafts-Verkehrskanälen gespeichert wird, und
dem Teilnehmer-Endgerät eine Liste der ersten Gruppe von Bereitschafts-Verkehrskanälen zugeführt wird.

7. Verfahren nach Anspruch 6,
dadurch gekennzeichnet, daß die auf der Liste befindlichen Bereitschafts-Verkehrskanäle an dem Teilnehmer-Endgerät dadurch als brauchbar bestimmt werden, daß:

jeder der auf der Liste angegebenen Bereitschafts-Verkehrskanäle der ersten Gruppe abgetastet wird,
der Störpegel jedes der Bereitschafts-Verkehrskanäle gemessen wird,
der Bereitschafts-Verkehrskanal mit dem niedrigsten Störpegel ausgewählt wird, und
der ausgewählte Bereitschafts-Verkehrskanal gespeichert wird.

8. Verfahren nach Anspruch 6 oder 6,
dadurch gekennzeichnet, daß die Bereitschafts-Verkehrskanäle auf der Liste dadurch an dem Teilnehmer-Endgerät als brauchbar bestimmt werden, daß

jeder der auf der Liste angegebenen Bereitschafts-Verkehrskanäle der ersten Gruppe abgetastet wird,
der Störpegel der Bereitschafts-Verkehrskanäle gemessen wird,
ein erster Bereitschafts-Verkehrskanal, bei dem ein Störpegel unterhalb eines zweiten Schwellenwertes festgestellt wird, ausgewählt wird, während die Bereitschafts-Verkehrskanäle abgetastet werden, und
der ausgewählte Bereitschafts-Verkehrskanal gespeichert wird.

Revendications

1. Procédé d'exécution d'une commutation intracellulaire d'appel d'un canal actuel de trafic, utilisé entre une station de base et un terminal d'abonné, à un canal de trafic en attente dans un système de communications radioélectriques, le procédé comprenant :

la sélection d'un premier groupe de canaux de trafic en attente, déterminés comme pouvant être utilisés à la station de base,
le contrôle de la qualité du signal dans le canal actuel de trafic,
la transmission d'une demande d'un nouveau canal de trafic lorsque la qualité du signal du canal actuel de trafic se détériore à un niveau inacceptable, et
la commutation de la station de base et du terminal d'abonné sur l'un des canaux de trafic en attente choisi dans le premier groupe de canaux de trafic,

caractérisé par

l'émission vers le terminal d'abonné d'un message par le canal de signalisation compris dans la bande reliant la station de base au terminal d'abonné, le message étant représentatif du premier groupe,
la réception du message par le terminal d'abonné,
la sélection, dans le premier groupe, d'un second groupe de canaux de trafic en attente déterminés comme pouvant être utilisés au terminal d'abonné, et
la transmission à la station de base, par le canal de signalisation de la bande, d'un message de réponse représentatif des canaux de trafic en attente du second groupe qui ont été déterminés comme pouvant être utilisés au terminal d'abonné,
le premier canal de trafic en attente étant choisi dans le second groupe.

2. Procédé selon la revendications 1, caractérisé en ce que le premier groupe de canaux de trafic en attente est sélectionné par les opérations suivantes :

le balayage, à la station de base, de chacun des canaux de trafic,
la mesure du niveau d'interférences de chaque canal de trafic, et
l'identification du canal de trafic comme canal utilisable de trafic en attente lorsque le niveau d'interférences est inférieur à un seuil prédéterminé.

3. Procédé selon la revendication 2, caractérisé en ce que des canaux supplémentaires utilisables de trafic en attente sont sélectionnés parmi plusieurs canaux de trafic disponibles pour le service lorsque le nombre de canaux de trafic en attente à des niveaux d'interférences inférieurs au premier seuil prédéterminé est déterminé comme non convenable.

4. Procédé selon la revendication 3, caractérisé en ce que, lorsque des canaux supplémentaires de trafic en attente qui peuvent être utilisés sont sélectionnés, des canaux supplémentaires de trafic en attente qui peuvent être utilisés ayant le niveau d'interférences le plus bas au-delà du premier seuil prédéterminé sont sélectionnés.

5. Procédé selon la revendication 4, caractérisé en ce que, lorsque des canaux restants de trafic en attente ont un niveau excessif d'interférences considéré comme donnant des communications non convenables entre la station de base et le terminal d'abonné, ils sont exclus de la sélection.

6. Procédé selon l'une quelconque des revendications précédentes, caractérisé en ce que le message est transmis au terminal d'abonné par les opérations suivantes :

la mémorisation du premier groupe de canaux de trafic en attente, et
l'envoi au terminal d'abonné d'une liste des canaux de trafic en attente du premier groupe.

7. Procédé selon la revendication 6, caractérisé en ce que les canaux de trafic en attente de la liste sont déterminés comme pouvant être utilisés au terminal d'abonné par les opérations suivantes :

le balayage de chacun des canaux de trafic en attente du premier groupe identifié dans la liste,
la mesure du niveau d'interférences de chacun des canaux de trafic en attente,
la sélection du canal de trafic en attente ayant le plus petit niveau d'interférences, et
la mémorisation du canal choisi de trafic en attente.

8. Procédé selon la revendication 6 ou 7, caractérisé en ce que les canaux de trafic en attente de la liste sont déterminés comme étant utilisables au terminal d'abonné par les opérations suivantes :

le balayage de chacun des canaux de trafic en attente du premier groupe, identifié dans la liste,
la mesure du niveau d'interférences des canaux de trafic en attente,
la sélection, lorsque les canaux de trafic en attente sont balayés, d'un premier canal de trafic en attente déterminé comme ayant un niveau d'interférences inférieur à un second seuil, et
la mémorisation du canal choisi de trafic en attente.

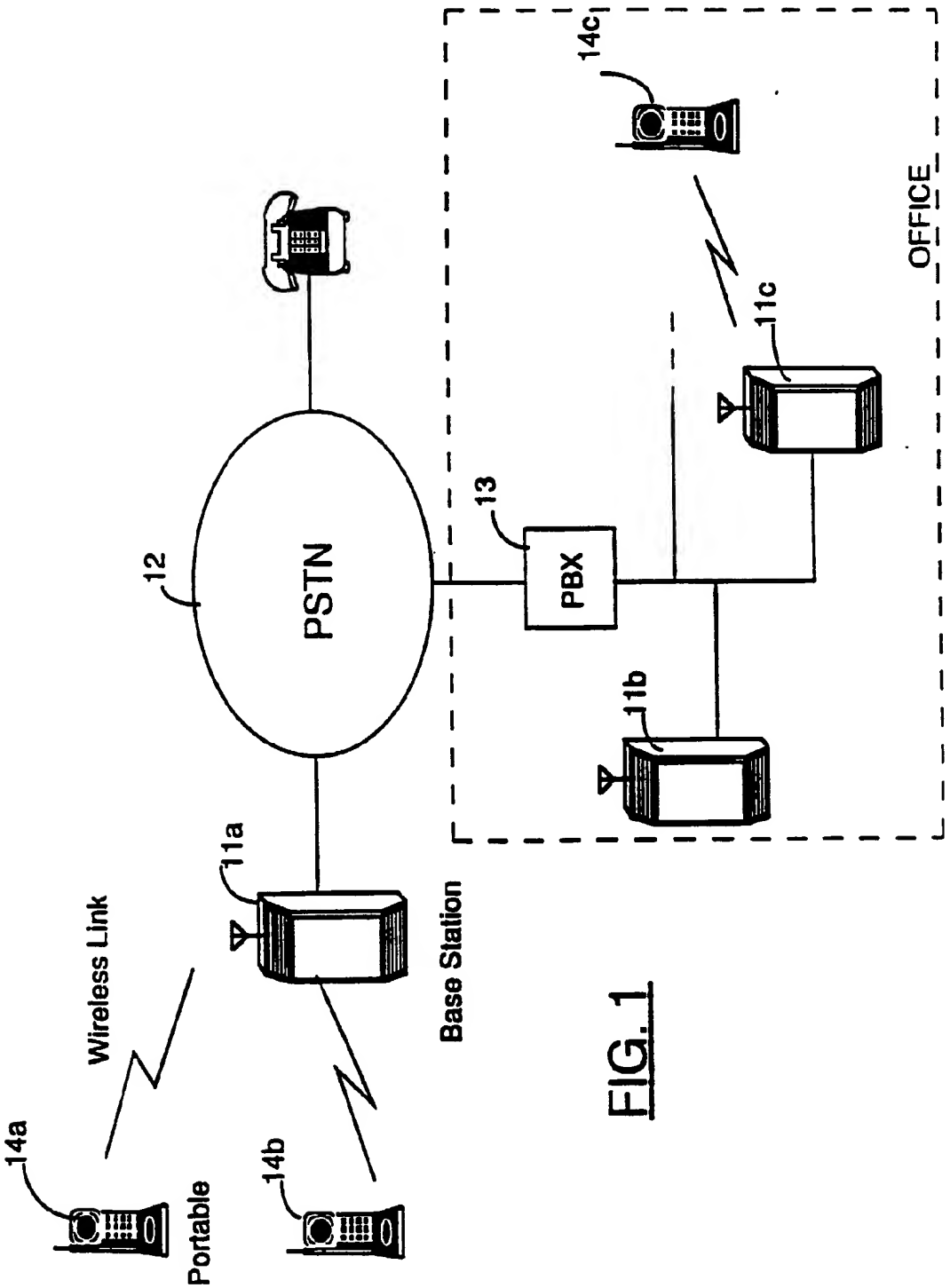
14a
Portable
Wireless Link
14b
11a
Base Station
12
PSTN
13
PBX
11b
11c
14c
OFFICE

FIG. 1

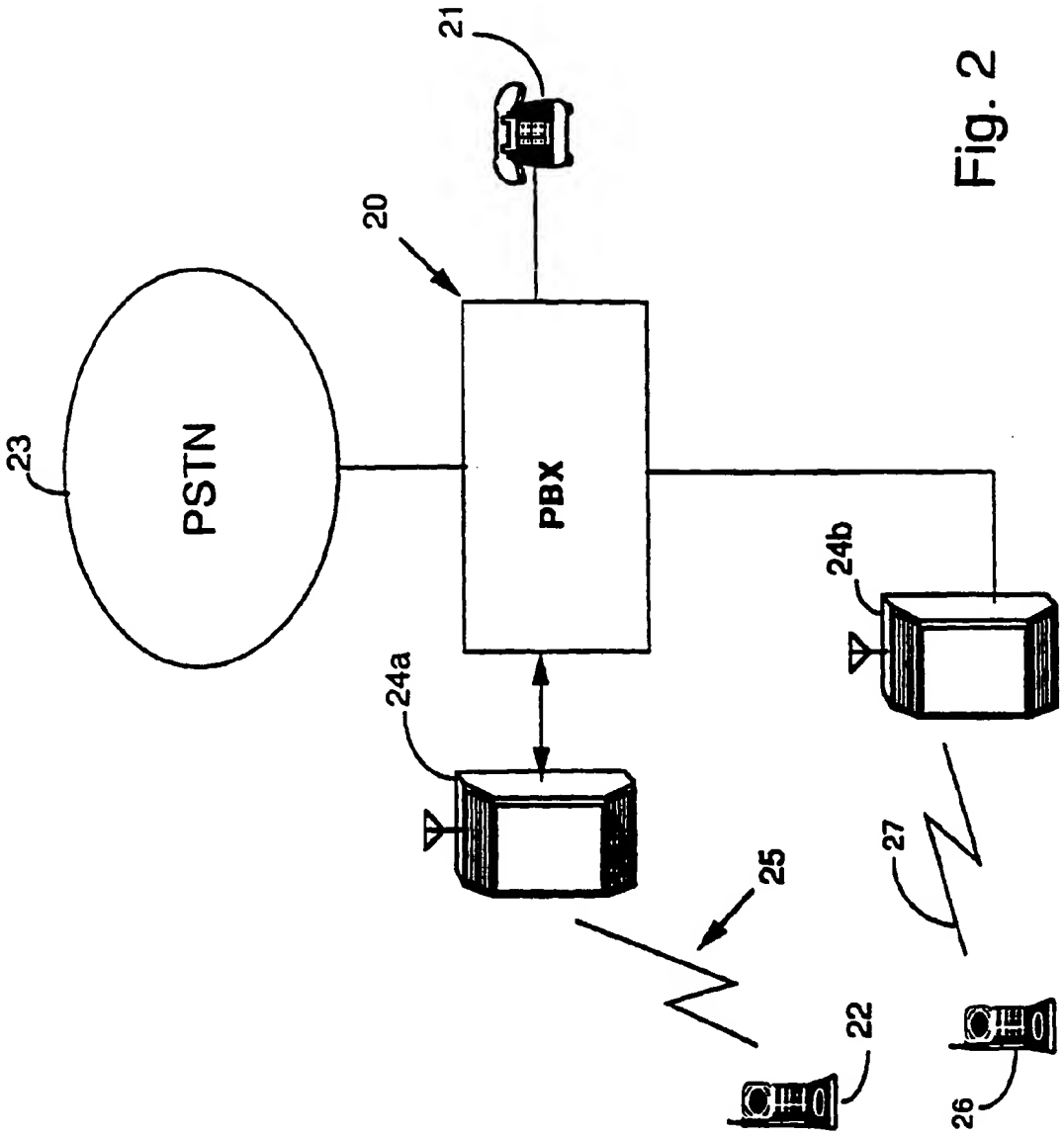

Fig. 2

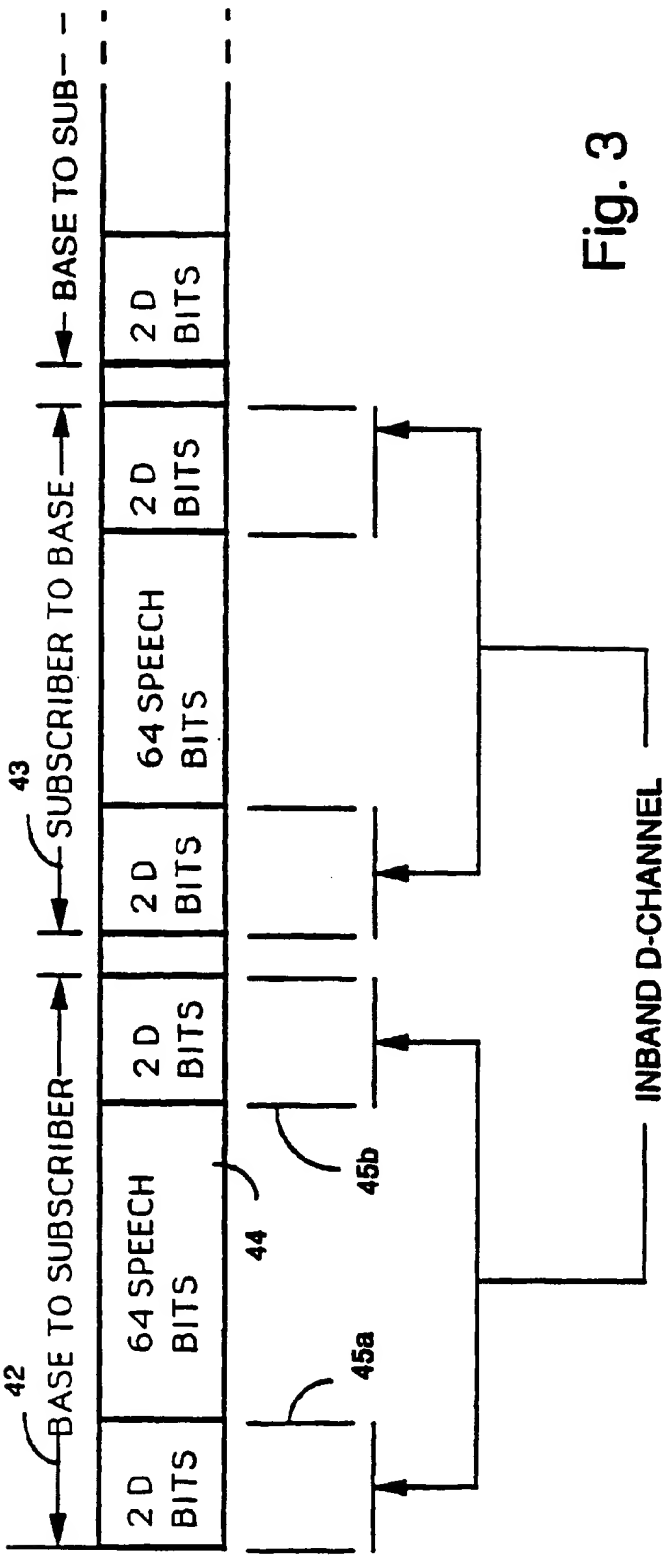
42
BASE TO SUBSCRIBER
2 D BITS
64 SPEECH BITS
2 D BITS
43
SUBSCRIBER TO BASE
2 D BITS
64 SPEECH BITS
2 D BITS
BASE TO SUB
44
45a
45b
INBAND D-CHANNEL

Fig. 3

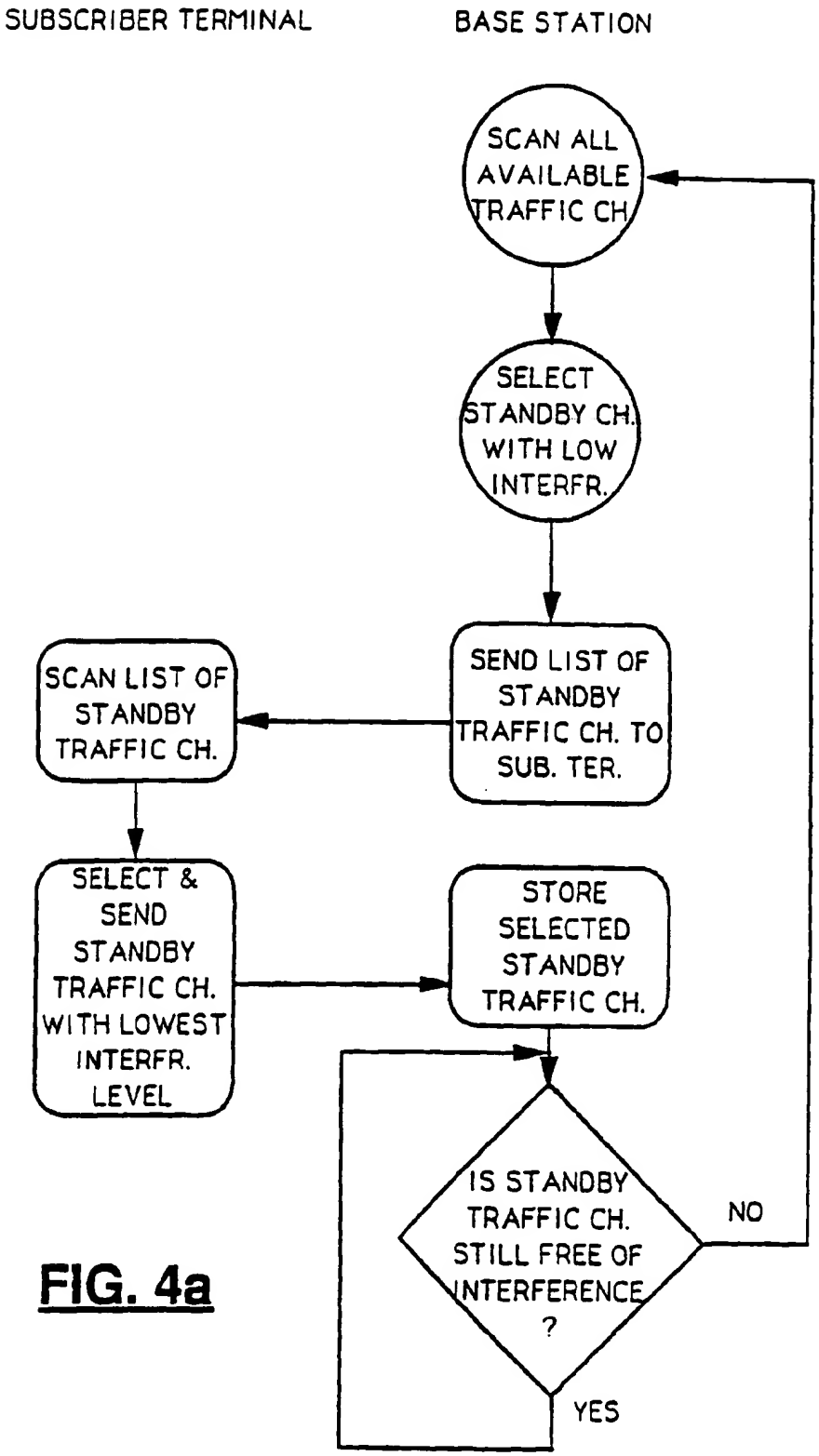
SUBSCRIBER TERMINAL
BASE STATION
SCAN ALL AVAILABLE TRAFFIC CH.
SELECT STANDBY CH. WITH LOW INTERFR.
SEND LIST OF STANDBY TRAFFIC CH. TO SUB. TER.
SCAN LIST OF STANDBY TRAFFIC CH.
SELECT & SEND STANDBY TRAFFIC CH. WITH LOWEST INTERFR. LEVEL
STORE SELECTED STANDBY TRAFFIC CH.
IS STANDBY TRAFFIC CH. STILL FREE OF INTERFERENCE ?
NO
YES

FIG. 4a

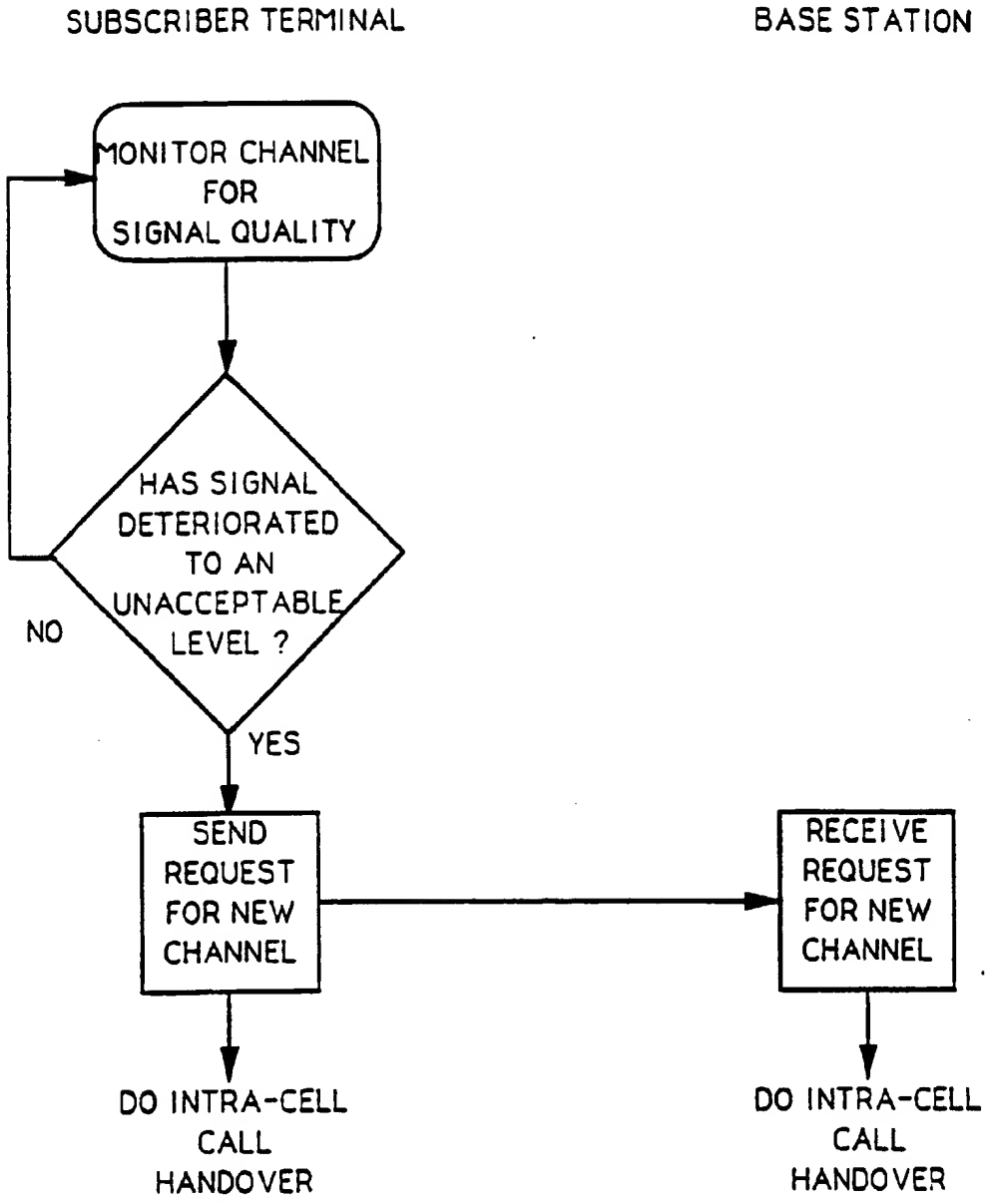
SUBSCRIBER TERMINAL
BASE STATION
MONITOR CHANNEL FOR SIGNAL QUALITY
HAS SIGNAL DETERIORATED TO AN UNACCEPTABLE LEVEL ?
NO
YES
SEND REQUEST FOR NEW CHANNEL
RECEIVE REQUEST FOR NEW CHANNEL
DO INTRA-CELL CALL HANDOVER
DO INTRA-CELL CALL HANDOVER

FIG. 4b

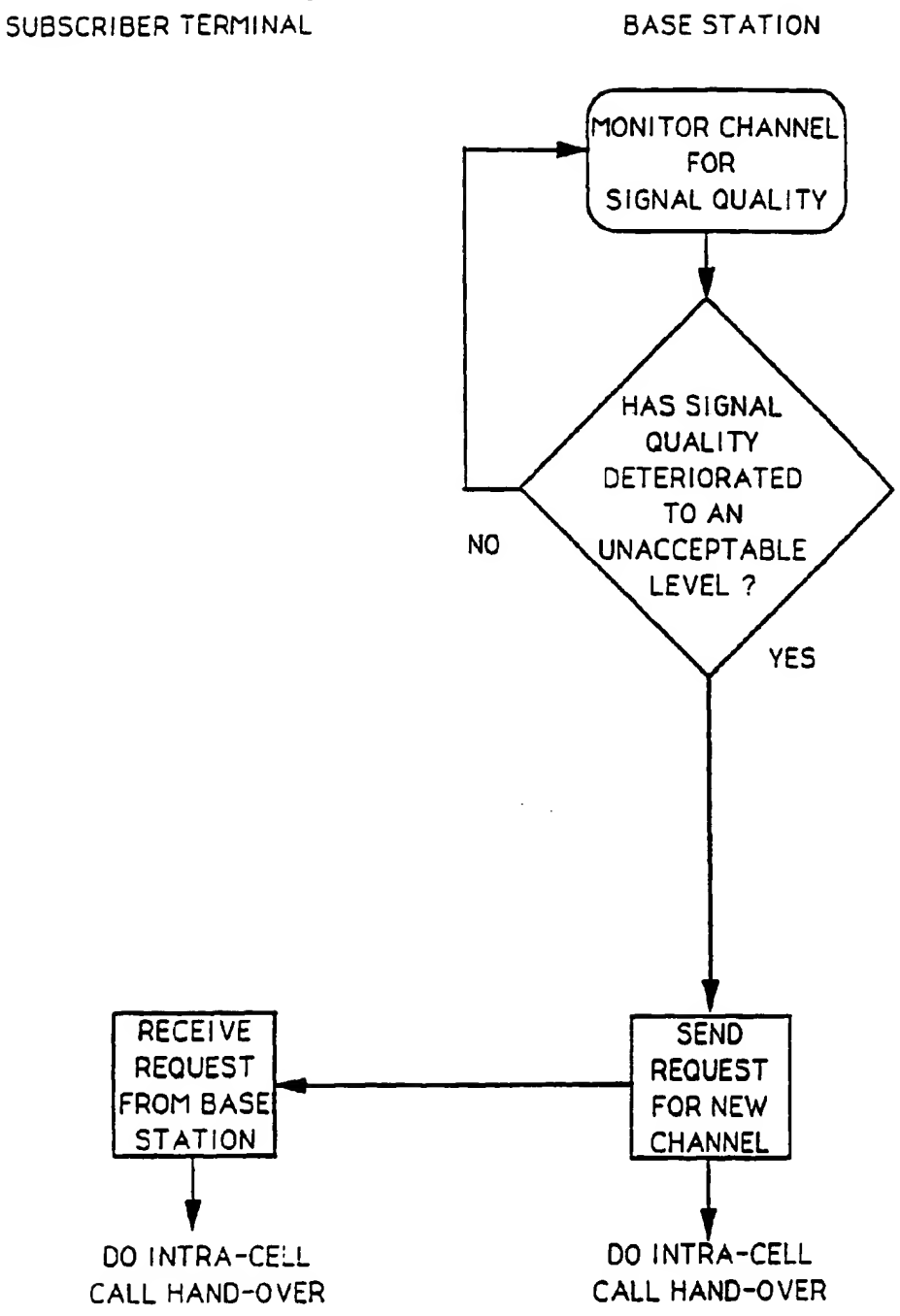
SUBSCRIBER TERMINAL
BASE STATION
MONITOR CHANNEL FOR SIGNAL QUALITY
HAS SIGNAL QUALITY DETERIORATED TO AN UNACCEPTABLE LEVEL ?
NO
YES
RECEIVE REQUEST FROM BASE STATION
SEND REQUEST FOR NEW CHANNEL
DO INTRA-CELL CALL HAND-OVER
DO INTRA-CELL CALL HAND-OVER

FIG. 4c